

Radiology Corner

Facial Blast Injury Resulting in Sand Aspiration

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Note: This is the full text version of the radiology corner question published in the December 2008 issue, with the abbreviated answer in the January 2009 issue.

Sand aspiration has been previously associated with drowning, cave in, and accidental burial. It can be a fatal complication due to obstruction of the airway and subsequent anoxic death. However, to the authors knowledge, it has not previously been associated with blast injuries. We discuss a recent case of a blast-injury survivor in Iraq with findings consistent with sand aspiration on computed tomography (CT) and review presentation, imaging findings, bronchoscopy findings and management.

Introduction

Sand aspiration is relatively rare, and is most commonly reported as a complication of drowning or near drowning.¹⁻⁴ Cases of sand aspiration have also been reported in situation ranging from sandcastle collapse⁵ to accidental burial⁶ or cave in.⁷ To our knowledge, similar findings have not previously been reported in association with blast injury. Aspiration of sand, which may contain material such as calcium carbonate or aluminum silicate, produces characteristic findings on both computed tomography (CT) and chest x-ray.^{3,8,9}

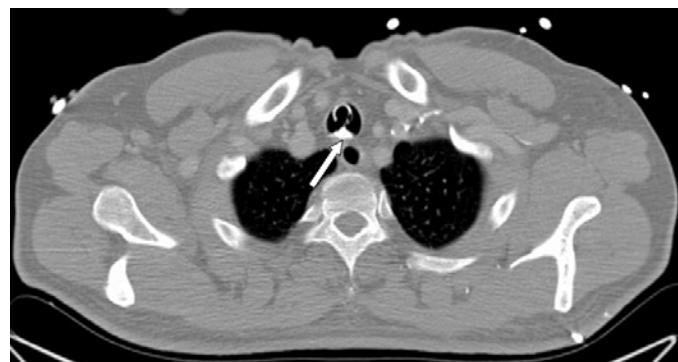


Fig. 1 Chest CT with radiodense material visible (arrow) in the dependent portion of the trachea (patient laying supine). ET tube is incidentally seen anterior to the sand deposit.

Summary of Imaging Findings

Chest CT imaging, obtained with the patient lying supine, revealed radiopaque material lining the dependant portions of the trachea as well as the main stem bronchi and bronchioles (see figure 1 and 2). No particulate matter was noted within the sinuses.



Fig. 2 Chest CT showing radiodense material within the right and left main stem bronchi (arrow).

Patient Discussion

A 34 year old male suffered a blast injury complicated by sand aspiration. The victim was facing the blast when it occurred. The patient was evacuated to the 332 EMDG (Expeditionary Medical Dental Group) in Balad, Iraq. He arrived with a Glasgow coma score of 15 and was hypotensive. Injuries sustained in the blast included multiple injuries including the face, left flank, back, left lower extremity, and an open distal tibia and fibula fracture with a retained foreign body. He was subsequently intubated in the emergency department for declining respiratory status. The patient was taken to the operating room for external fixation and wound debridement. Following surgery, the patient was taken to the ICU and extubated.

On hospital day 2, copious thick fluid described as "muddy" was suctioned from the respiratory tract, at which time a well tolerated bronchoscopy was performed. The bronchoscopy was notable for mild mucosal inflammation and a finding of yellow "mud" adherent to both the tracheal wall and the upper bronchi. CT imaging of the chest showed foreign radiopaque material in the trachea and bronchi consistent with aspirated sand. Empiric antibiotic coverage with meropenem for *actinobacter* was started, as well as levoquin and cefazolin.

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The patient was transferred to the ward from ICU on hospital day 2 following improvement in his respiratory status. Over the next several days the patient was taken back to the operating room for revision and further repair of extremity injuries. He continued to recover, and was discharged on hospital day 14 with no further pulmonary complications.

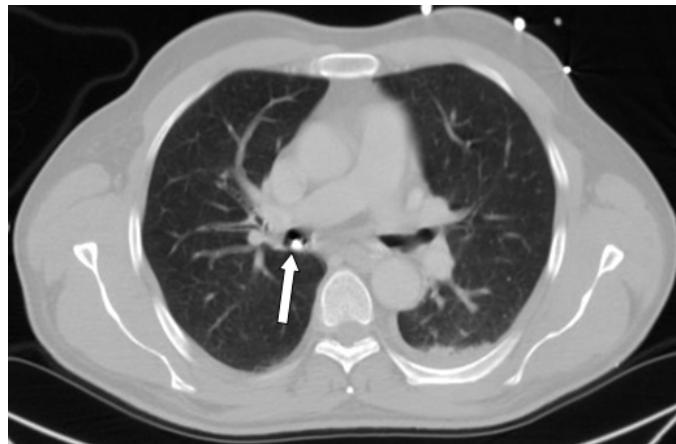


Fig. 3. Sand material seen again in right mainstem bronchus (arrow).

Discussion

The first reported case of sand aspiration described a patient following drowning, with subsequent significant difficulty during cardiopulmonary resuscitation due to obstruction of the oropharynx and mouth with sand.² Other reports have described sand aspiration in the context of cave-ins, drowning and near drowning, and even sand castle collapse.^{3-8,10} Sand, as defined by Keunen, consists of aggregates of sedimentary particles whose individual diameters fall between 0.5 and 2 millimeters, with larger particles considered gravel and smaller particles considered silt. The exact composition of the material varies by location. Sand aspirated from ocean water often contains calcium carbonate from fragmented seashells, which allows sand to be visualized radiographically.³

The presentation of sand aspiration is highly variable. Certainly, sand visible within the oral cavity, oropharynx, or nasal passages can be indicative of sand aspiration in the correct clinical context. Clinical presentation can range from rapid death due to total occlusion of the airway and subsequent anoxic death to a spectrum of dyspnea, cough, and variable obstructive symptoms.^{2-8,10} A prominent feature in the presentation of an automobile accident victim, who aspirated sand, was significantly elevated peak airway pressure and difficulty with ventilation support.⁴

In the past, the focus of reported radiographic imaging in sand aspiration has been on chest x-ray. Findings on chest roentgenograms may be highly variable, however Bonilla-Santiago described a characteristic "sand bronchogram" in two patients suffering from sand aspiration.³ Both of these patients exhibited particulate matter filling the bronchial tree as evidenced by radiodense material lining the central tracheobronchial tree in one case and linear radiodense opacities in the other. In reported cases of particulate aspiration following accidental burial or cave-in, similar classic sand bronchograms have been reported.^{5-7,10} Other

findings on x-ray are highly variable, ranging from near normal imaging to pulmonary edema characterized by fluffy, confluent, nodular perihilar opacities.^{3,4,8} The general pattern is that of opacification of the airway involved in aspiration.⁷

More recent reports have included CT imaging of sand aspiration, though it is not routinely obtained and reports specifically detailing CT findings are limited in number.^{4,8} In a recent retrospective examination of post-mortem CT (as opposed to conventional autopsy) in the diagnosis of drowning victims, sand and sediment in the bronchial tree were visualized by CT on nearly half of the drowning victims.¹ This finding raises the possibility that sand aspiration has been historically under-recognized in drowning and near-drowning incidents.

On CT, it may be possible to appreciate sand bronchograms in the form of radiodense material filling the bronchial tree, similar to those previously described for plain chest films. These findings may be more apparent in CT imaging when relatively subtle on chest x-ray.⁴ Additionally, aspirated material may be visible in the trachea as radiodensities, as it was in this case's presentation. Findings of air fluid levels in the sinuses, while nonspecific and present in a wide variety of situations, can be suggestive of either drowning or aspirated material.^{1,11,12} Dunagan, et al reported findings of air-fluid-sand levels in the maxillary sinuses in one near drowning patient with sand aspiration. CT is not routinely recommended, however the true utility of CT in these instances has not been determined.^{4,8} In the setting of conclusive plain film radiographic findings, CT may not be necessary. There is increasing interest in the use of post-mortem CT in the evaluation of drowning patients which may in time be expanded to use in near-drowning and other causes of sand aspiration with equivocal chest x-ray findings. Post-mortem CT may be especially valuable in determining the course of events and progression of injury leading to death.

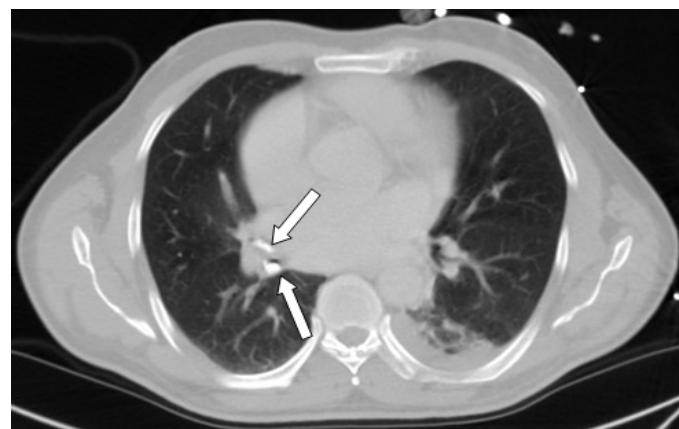


Fig. 4 Inferior chest CT showing radiodense material within the right segmental bronchi (arrows).

Bronchoscopy has proved beneficial in a number of cases, particularly when conservative treatment has failed or the patient's respiratory function becomes compromised by the aspirated material.^{4,7,8} Some have advocated conservative management, consisting of postural drainage and oxygen supplementation with or without bronchodilators.^{6,7}

Conservative management, in a patient not threatened with respiratory failure and if successfully performed, offers the possibility of clearing airways outside the reach of bronchoscopy as well as avoiding an invasive procedure. Bronchoscopy allows both direct visualization of the extent and degree of injury as well as removal of some of the aspirated material. Successfully retrieved material may be used for culture in order to determine appropriate antibiotic coverage, if deemed necessary.⁴ Lavage may be required in order to successfully remove fine, smaller diameter particles. Alternatively, some particles may prove too large to successfully remove via a bronchoscope. Reported findings on bronchoscopy include inflammation and erythema of the airway, mucosal friability, evidence of direct foreign body injury to the airway, as well as the aspirated material itself.^{4,6,8,10} It is also possible for the sand to mix with mucus secretions, forming a gritty cast-like plug which can impact and further occlude the airway.⁵ However, bronchoscopy in blast patients is best understood in the setting of thermal injury, rather than aspiration as found in this case.¹³

The patient described in this report suffered a blast injury, rather than submersion near-drowning or a variation of cave in. This different primary mechanism of injury necessitates consideration of pulmonary damage due to barotrauma secondary to the blast itself. Further, the patient exhibited multiple additional wounds, consistent with close exposure to an explosive device. Blast lung, as the condition has been termed, is the second most common manifestation of primary organ damage in blast injuries and is due to the pressure differential across the alveolar-capillary interface.¹⁴ Pulmonary injury can be sustained without evidence of external thoracic injury when the pressure wave carries sufficient force to compress the chest wall posteriorly against the spine. The result is a transient elevation in intrathoracic pressure.¹⁵ The classic imaging finding in pulmonary barotrauma, not present in this case, is described as a bihilar “butterfly” pattern consistent with pulmonary contusion. Additional findings may include pulmonary infiltrates, pneumothorax, and hemothorax among others.^{14,15}

Conclusion

Sand aspiration is a rare complication of a variety of injury mechanisms ranging from drowning to blast injury, which should be considered in the setting of the appropriate history and findings of respiratory distress or obstruction. The aspirated material produces characteristic findings on chest x-ray and CT. While x-ray imaging may support a diagnosis in cases of sand aspiration, increasing interest has been shown in the utility of CT post-mortem in drowning and equivocal x-ray findings in cases of near drowning with sand aspiration. To

our knowledge, aspirated sand has not been previously reported in conjunction with blast injury.

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